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The Comparison of Ventilatory Threshold (VT) During Running and Cycling Exercise in the Menstrual Phases

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Abstract: The purpose of this study was to determine the ventilatory threshold during two incremental exercises in both the early follicular and luteal phases of the menstrual cycle in twenty healthy untrained females. Early follicular was in the fourth day of the menstrual cycle and the luteal phase was determined by the level of Gnadotropin and Progesterone hormones in serum blood samples. The participants were randomly classified in two equal groups (Treadmill; T and Cycle Ergometer; CE). The participants performed an incremental exercise on a cycle Ergometer and treadmill during their early follicular and luteal phases until they were exhausted. The pulmonary gas analyzer (K4B2) was applied to measure the minute ventilation (V_E), Ventilatory equivalents of oxygen consumption (V_E/VO_2) and Ventilatory equivalents for carbon dioxide production (V_E/VCO_2) in early follicular and luteal phases of the menstrual cycle. Paired t-tests were performed to detect baseline differences across menstrual phases. The results indicated no significant differences ($p>0.05$) in VE, ventilatory equivalents (V_E/VO_2, V_E/VCO_2) across the menstrual cycle of in untrained females. In conclusion, these results suggest that menstrual cycle hormones did not affect the ventilatory threshold at incremental exercise in untrained females. Moreover, the differences between the averages of ventilatory equivalents (V_E/VO_2, V_E/VCO_2) in two modes of exercise were not significant in both groups of participant T and CE ($P<0.05$).

Key words: Ventilatory threshold · Follicular and luteal phases · Incremental exercise · Untrained females

INTRODUCTION

Identifying key elements that contribute to performance is an exhaustive process. Low levels of estradiol and progesterone are found in the early follicular phase of the menstrual cycle, whereas high levels are found in the midluteal phase. The effects of menstrual cycle hormones on exercise performance have been studied previously. However, the results remain controversial. The primary effects of estradiol and progesterone are related to reproductive behavior, but a number of reviews have addressed the role both progesterone and estradiol play in stimulating minute ventilation (V_E) [1, 2]. Exercise VE plays a critical role in providing O_2 to exercising muscles. However, exercise VE is not considered to be a limiting factor during exercise, given that normal healthy individuals rarely approach mechanical or diffusion limitations even at maximal exercise intensities [3]. Particularly, the respiratory responses to progressive intense exercise have shown inconsistent results. Several studies show higher exercise minute ventilation (V_E) during the luteal phase compared to the follicular phase [4, 5] while other studies show no difference [6, 7]. The effect of cyclic variations in ovarian hormones on exercise V_E continues to be unclear. The luteal and the follicular phase have shown differences for maximal V_E as high as 12 L/min with no effect on VO_{2max} [8, 9]. Numerous studies have also suggested the impact of menstrual cycle hormones on VO_{2max} or exercise performance appears to be minimal [10, 11]. There are inconsistent reports in the literature on the effect of sex on the ventilatory equivalents of oxygen (V_E/VO_2) and carbon dioxide (V_E/VCO_2) during exercise. Some have demonstrated no differences [8, 12] and others have

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shown a significantly higher V_E/VCO_2 in women compared to men [13]. Neither the Blackie *et al*. [12] nor the Habedank *et al*. [13] studies accounted for menstrual cycle phase [12, 13]. The differences in V_E/VCO_2 can be greater during the luteal phase [7]; however, this is also controversial [9]. De Souza *et al*. [14] observed no differences in oxygen uptake, VE, heart rate, respiratory exchange ratio (RER), rating of perceived exertion (RPE), time to fatigue and plasma lactate following maximal and sub maximal exercise tests between the follicular and luteal phases in eumenorrheic and amenorrheic runners. Also, the results suggest that neither the follicular or luteal phases alter exercise performance in female athletes [14]. The V_E/VCO_2 relationship can be stated as the absolute change in V_E per unit change in VCO_2 or as the y-intercept and has been used to evaluate the appropriateness (efficiency) of minute ventilation during exercise. There are inconsistent reports of the effect of gender on the exercise V_E/VCO_2 where some have demonstrated no differences [12] and others have shown a significantly higher V_E/VCO_2 in women compared to men [13]. However, neither of the two studies accounted for the menstrual cycle phase and the differences can possibly be greater throughout the luteal phase [7, 8]. Furthermore, Schoene *et al*. [15] Has demonstrated that V_E/VO_2 during progressive exercise on a bicycle Ergometer was significantly increased throughout the luteal phase compared to the follicular phase. In particular, the ventilatory responses to progressive intense exercise have shown mixed results. It is thought that the higher levels of circulating estrogen and progesterone are the stimuli for altered ventilatory responses during the luteal phase of the cycle.

The purpose of this investigation was to compare different mode of testing ventilatory threshold in the early follicular and luteal phases of the menstrual cycle of inactive women. The results of the study could enhance our understanding of the hormonal influences on breathing during exercises that occur during the menstrual cycle. The results could have an impact on exercise rehabilitation programs for patient populations, exercise prescription for disease prevention in healthy individuals and training strategies for competitive athletes.

MATERIAL AND METHOD

Twenty healthy, active Females between the age of 19 and 25 yr with no known history of cardiopulmonary, metabolic or musculoskeletal disease were recruited in this study. All subjects demonstrated a normal menstrual cycle during the previous 4 months as determined by the medical history form and were not currently using birth control medications. The participants included twenty healthy untrained females who hadn't taken part in any regular physical activities and freely volunteered to participate in the study.

Subjects were randomly classified in two equal groups (Treadmill; T and Cycle Ergometer; CE). The age, weight and height of participants were respectively 22±3 yrs, (55.32±4.16) kg and (163 ±5.51) cm in T: untrained group and 22±3 yrs, (56.56±5.78) kg and (162±4.30) cm in C: untrained group. Early follicular was in the fourth day of the menstrual cycle and the luteal phase was determined by the level of Progesterone, Prolactin, FSH and LH hormones in serum blood samples (RIA-method). An incremental graded exercise test (GXT) was conducted on a cycle ergo meter (Techno Gym) and Treadmill (Cosmed-Italy). On the cycle Ergometer: After a 5-min warm up at 50 W, the subjects rode a progressive exercise test (25 W/min), until they were unable to continue [16]. The pulmonary gas analyzer (K4B2- Casmed) was applied to measure the, minute ventilation (VE), ventilatory equivalents (VE/VO2, VE/VCO2) in two phases. All testing was conducted in accordance with the guidelines of the American College of Sports Medicine [17] in the measurement center of the Olympic committee [17]. Paired T-test was used to determine the differences in minute ventilation, ventilatory equivalents V_E/VO_2 and V_E/VCO_2 during the follicular and luteal phases of incremental exercise. Significance was set at the 0.05 level. All statistical analysis was performed utilizing SPSS, version 13.

RESULTS

The results indicated no significant differences in maximal V_E across the menstrual cycle ($p>0.05$). The ventilatory equivalents V_E/VO_2 and V_E/VCO_2 showed no significant differences ($p>0.05$) across the menstrual cycle and in two modes of exercise (T and C). V_E/VO_2 at maximal exercise for the follicular and luteal phases in T: untrained group was 41.49±7.23 and 43.54±6.94, C: group was 41.59±6.96 and 41.72±6.82 respectively (Table 1). VE/VCO2 at maximal exercise for the follicular and luteal phases in T: untrained group was 38.94±5.82 and 38.91±5.50, C: group was 37.21±3.89 and 34.59±4.64 respectively (Table 1).

Table 1: Maximal exercise test variables.

Groups	Variable	Follicular	Luteal
Treadmill	VE	88.89±13.60	85.47±9.56
	VE/VO2	41.49±7.23	43.54±6.94
	VE/VCO2	38.94±5.82	38.91±5.50
Cycle Ergometer	VE	68.47 ±13.25	61.88 ±11.10
	VE/VO2	41.59±6.96	41.72±6.82
	VE/VCO2	37.21±3.89	34.59±4.64

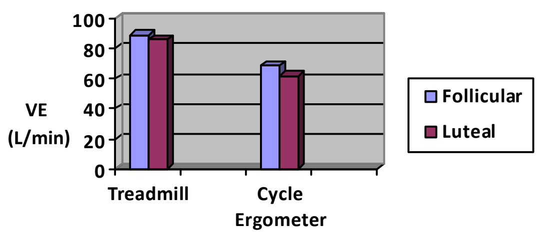

Fig. 1: Minute Ventilation (VE) at incremental exercise during the follicular and luteal phases of the menstrual cycle. Values are means + SD.

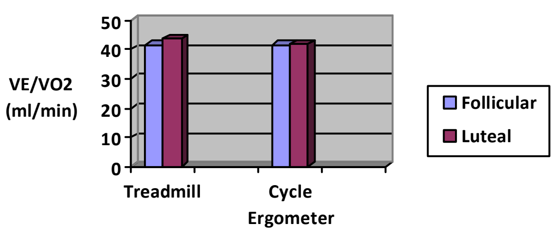

Fig. 2: Ventilatory equivalents for oxygen consumption (VE/VO2) at incremental exercise during the follicular and luteal phases of the menstrual cycle. Values are means + SD.

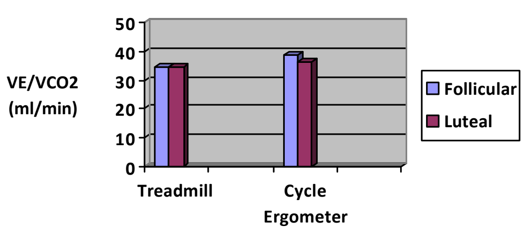

Fig. 3: Ventilatory equivalents for carbon dioxide production (VE/VCO2) at incremental exercise during the follicular and luteal phases of the menstrual cycle. Values are means + SD.

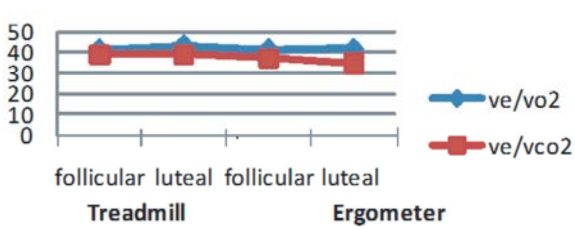

Fig. 4: Comparison of Ventilatory Threshold (VT) during running and cycling exercise in follicular and luteal phases. Values are means + SD.

DISCUSSION

The major finding of this study suggests that menstrual hormones did not affect breathing responses at maximal exercise. Additionally, there were no significant differences in gas exchange variables during a maximal graded exercise test between the follicular and luteal phases of the menstrual cycle. Menstrual cycle hormones did not affect respiratory stimulation across the menstrual cycle at maximal V_E. Our results are in agreement with Beidleman *et al*. [9], Casazza *et al*. [18], Dean *et al*. [19], Bemben *et al*. [16], De Souza *et al*. [14], Hackney *et al*. [20], Stephenson *et al*. [21] and Lebrun *et al*. [11]. The Beidleman *et al*. [9] study showed that peak V_E and sub maximal V_E were not affected by menstrual cycle phase [9]. However, other studies have shown significant differences in exercise V_E during the luteal phase of the menstrual cycle [4, 5]. The varying results between these studies and the current study could be related to individual responses and differences in progesterone receptor sensitivity [18]. In addition, it is widely accepted that ventilatory measures demonstrate large within-subject daily variability. The ventilatory equivalents (V_E/VO_2 and V_E/VCO_2) were not elevated during the luteal phase in the incremental exercise compared to the follicular phase. Our study is one of the few studies to account for menstrual cycle phase for these variables. Beidleman *et al*. [6] and Bemben *et al*. [9] had similar findings that showed no significant differences ($p > 0.05$) in the ventilatory equivalents in the follicular and luteal phases of the menstrual cycle. Nonetheless, Schoene *et al*. [15] results showed V_E/VO_2 was significantly greater at all levels of exercise in the luteal phase. However, he did not show a significant correlation between respiratory variables and plasma progesterone. It is not surprising that V_E/VO_2 and V_E/VCO_2 were not elevated in the current study as neither VE, VO_2 nor VCO_2 were different between menstrual phases at maximal level of exercise. Controversy regarding the effect of ovarian hormones on ventilatory chemosensitivity is probably due to *1*) a wide range of estradiol and progesterone among subjects in the same study, as well as between studies, *2*) individual responds to a given ovarian hormone level and *3*) the relatively large within-subject, between-day variability inherent in measures of ventilator chemosensitivity [22]. Additionally, the differences between the average of ventilatory equivalent in two modes of exercise were not significant in both groups of participants ($P<0.05$). The Martinez *et al*. [23] study showed that the greater slow component observed in cycling compared to running may be related to differences in the muscle contraction regimen that is required for the two exercise modes. It has been reported that peak tension developed during each pedal thrust was higher in maximal cycling than in running. This tension difference implies a greater fast-twitch fiber recruitment and, hence, a greater anaerobic contribution. They explained that the contraction portion of the contraction-relaxation cycle is prolonged in cycling. In contrast, Running is more of a ballistic movement with a very short contraction phase and less impairment of muscle blood flow.

CONCLUSION

It seems that because of the physical depression during menstrual cycle, which is due to the female untrained, the replacement of running with cycling, with the aim of making physical activity simpler and encouraging female to continue their activity during this time, is recommendable. In conclusion, these results suggest that the menstrual cycle phase did not affect breathing responses at maximal exercise. Additionally, there are no differences in maximal exercise test variables between the follicular and luteal phases of the menstrual cycle. These results provide additional data suggesting that the timing of the menstrual cycle phase may not be as critical as once thought when designing future exercise ventilation studies. This may have important implications for individuals whose work, athletic competition, or recreation schedules.

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REFERENCES

1. Bayliss, D.A. and D.E. Millhorn, 1992. Central neural mechanisms of progesterone action: application to the respiratory system. Journal of Applied Physiology, 73: 393-404.
2. Lyons, H.A., 1976. Centrally acting hormones and respiration. Journal of Pharmacology & therapeutics B, 2: 743-751.
3. Dempsey, J.A., 1986. Is the lung built for exercise?. Medical science and Sports Exercise, 18: 143-155.
4. Jurkowski, J.E., N.L. Jones, C.J. Toews and J.R. Sutton, 1981. Effects of menstrual cycle on blood lactate, O2 delivery and performance during exercise. Journal of Applied Physiology, 51: 1493-99.
5. William, T.J. and G.S. Krahenbuhl, 1997. Menstrual cycle phase and running economy. Medicine Science Sports Exercise, 29: 1609-1618.
6. Bemben, D.A. P.C. Salm and A.J. Salm, 1995. Ventilatory and blood lactate responses to maximal treadmill exercise during the menstrual cycle. Journal of Sports Medicine & Physical Fitness, 35: 257-262.
7. Dombovy, M.L., H.W. Bonekat and T.J. Williams, 1987. Exercise performance and ventilatory response in the menstrual cycle. Medicine Science Sports Exercise, 19: 111-117.
8. Sheel, A.W., J.C. Richards, G.E. Foster and J.A. Guenette, 2004. Sex differences in respiratory exercise physiology. Sports Medicine, 34: 567-579.
9. Beidleman, B.A., P.B. Rock, S.R. Muza, C.S. Fulco, V.A. Forte And A. Cymerman, 1999. Exercise VE and physical performance at altitude are not affected by menstrual cycle phase. Journal of Applied Physiol., 86: 1519-1526.
10. Bryner, R.W., R.C. Toffle and I.H. Ullrich, 1996. Effect of low dose oral contraceptives on exercise performance. British Journal of Sports Medicine, 30: 36-40.
11. Lebrun, C.M., D.C. McKenzie and J.C. Prior, 1995. Effects of menstrual cycle phase on athletic performance. Medicine Science Sports Exercise; 27: 437-444.
12. Blackie, S.P., M.S. Fairbarn and N.G. McElvaney, 1991. Normal values and ranges for ventilation and breathing pattern at maximal exercise. Chest, 100: 136-142.
13. Habedank, D., I. Reindl and G. Vietzke, 1998. Ventilatory efficiency and exercise tolerance in 101 healthy volunteers. European Journal of Applied Physiology Occup Physiol., 77: 421-426.
14. De Souza, M.J. Maguire, M.S. Rubin, K.R, 1990. Effects of menstrual phase and amenorrhea on exercise performance in runners. Medicine Science Sports Exercise, 22: 575-580.
15. Schoene, R.B. H.T. Robertson, D.J. Pierson and A.P. Peterson, 1981. Respiratory drives and exercise in menstrual cycles of athletic and nonathletic women. Journal of Applied Physiology, 50: 1300-1305.

16. Hopkins, S.R., R.C. Barker, T.D. Brutsaert, T.P. Gavin, P. Entin, I.M. Olfert, S. Veisel and P.D. Wagner, 2000. Pulmonary gas exchange during exercise in women: effects of exercise type and work increment. Journal of Applied Physiology, 89: 721-730.
17. American College of Sports Medicine, Guidelines for Exercise Testing and Prescription 2000. (6^{th} Eds). Chapter 4, 57-90. Lippincott, Williams and Wilkins: Philadelphia, PA.
18. Casazza, G. Suh, B. Sh. Miller, F. Navazio and G. Brooks, 2002. The effects of oral contraceptives on peak exercise capacity. Journal of Applied Physiology, 93: 1698-1702.
19. Dean, T.M., L. Perreault, R.S. Mazzeo and T.J. Horton, 2003. No effect of menstrual cycle phase on lactate threshold. Journal of Applied Physiol., 95: 2537-2543.
20. Hackney, A.C., C.S. Curley and B.J. Nicklas, 1991. Physiological responses to submaximal exercise at the mid-follicular, ovulatory and mid-luteal phases of the menstrual cycle. Scandinavian Journal of Medicine Science Sports, 1: 94-98.
21. Stephenson, L.A., M.A. Kolka And J.E. Wilkerson, 1982. Metabolic and thermoregulatory responses to exercise during the human menstrual cycle. Medicine Science Sports Exercise, 14: 270-275.
22. Sahn, S.A., C.W. Zwillich, N. Dick, R.E. McCullough, S. Lakshminarayan and J.V. Weil, 1977. Variability of ventilator responses to hypoxia and hypercapnia. Journal of Applied Physiol., 43: 1019-1025.
23. Martinez, M.L., A. Modreg, J. Ibanez Santos, A. Grijalb, M.D. Santesteban and E.M Gorostiaga, 1993. Physiological comparison of roller skating, treadmill running and Ergometer cycling. International Journal of Sports Medicine, 14: 72-77.